MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2018/2019

EEE 7276 – DESIGN OF ON AND OFF GRID PV SYSTEMS

8 MARCH 2019
10.00 am – 1.00 pm
(3 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 4 pages including cover page with 5 Questions only.
2. Answer **ALL** questions. The distributions of marks for each question are as stated.
3. Please write all your answers in the Answer Booklet provided.

Question 1

(a) Define the following terms:

(i) Peak sun hour (PSH) [3 marks]
(ii) Latitude angle (φ) [3 marks]
(iii) Longitude angle (λ) [3 marks]

(b) Find the position of the sun (altitude angle, α and azimuth angle, ψ) at Kuala Lumpur (KL) on July 1 at 3:00 p.m. local time. The latitude and longitude of KL are 3.140° N and 101.69° E, respectively. The time zone of KL is based on the longitude 120° E. Neglect correction due to equation of time.

[Hint: Use the following formula to compute the solar altitude and azimuth angles:

$$\sin\alpha = \sin\delta \sin\varphi + \cos\delta \cos\varphi \cos\omega, \text{ and } \cos\psi = \frac{\sin\alpha \sin\varphi - \sin\delta}{\cos\alpha \cos\varphi}]$$

[11 marks]

Question 2

(a) State *True* or *False*

(i) An electron bond can be broken by the action of light or heat. [2 marks]
(ii) Intrinsic conductivity cannot be used to generate electricity. [2 marks]
(iii) PV cells are modelled as a current source in series with a diode. [2 marks]

(b) Calculate the maximum power, cell efficiency and fill factor of a cell at the intensity of 100 W/m^2, given

$V_{OC} = 0.24$ V
$I_{SC} = 9$ mA
$V_{MP} = 0.14$ V
$I_{MP} = 7$ mA
Area of the cell = 4 cm^2 [8 marks]

Continued.....

(c) A 36-cell module has an NOCT of 46° C with V_{OC}=19.4 V, when G = 0.8 kW/m^2, calculate

(i) the cell temperature when the ambient temperature rises to 30° C and G increases to 1 kW/m^2, and [4 marks]

(ii) the open-circuit voltage due to the change in cell temperature. [2 marks]

Question 3

(a) Draw a simple Grid-connected PV system suitable for residential applications without storage system. [7 marks]

(b) Design a Grid-connected PV system of rating 7 kW. The design should cover the following:

(i) Number of PV panels, number strings and panel per strings.
(ii) Number and rating of the blocking diodes.
(iii) Cable sizing, and
(iv) Rating of disconnect switches.

The data given are:
PV panel rating: 305 Wp, V_{OC} = 64.2 V, I_{SC} = 5.96 A, V_{MP} = 54.7 V, and I_{MP} = 5.58 A.
Inverter rating: 7000 W, V_{OC} = 600 V, V_{MP} = 250 – 480 V,
Output voltage = 240 V_{AC}.
Distance between PV strings and combiner = 15 m
Distance between combiner and Inverter = 40 m

The available cable wire sizes: 2.5 mm^2, 4 mm^2 and 10 mm^2. The resistivity of the cable wire is 1.68 x 10^{-8} Ω-m. [13 marks]

Question 4

(a) State the differences between Grid-connected and Stand-alone PV systems. [6 marks]

(b) Draw the figure that shows the principle of coupling PV systems with single and three-phase inverters to the electricity grid. [7 marks]

Continued.....

(c) In a Stand-alone PV system, the power required by the load is 800 W_{AC} for 8 hours per day. The battery voltage of the system is 24 V_{DC} and the battery trip efficiency is 0.85. The inverter efficiency is 0.9. The solar irradiation at the place = 4.1 kWh/m^2 per day. Calculate the number of PV panels required, if the panel rating is 130 Wp.

[7 marks]

Question 5

(a) State and briefly discuss the various types of mechanical loads acting on the installed PV arrays. [7 marks]

(b) A Stand-alone PV system consists of 60 PV panels each with the rating of 23.2 Wp, a group of batteries with the rating of 1500 Ah, a battery charger with the steady charging rate of 50 A, and an inverter of rating 1020 W. It supplies a total residential load of 5.05 kWh/day. The cost of each component of the PV system is given in the following table:

Item	PV panels	Battery	Charger	Inverter	Installation cost	Maintenance cost/Year
Cost	\$2.5/Wp	\$1.705/Ah	\$5.878/A	\$0.831/W	10% of PV cost	2% of PV cost

The lifetime of all the items is 20 years, except that of the battery which is considered to be 5 years. Assume an inflation rate, i of 3% and an interest rate, d of 10%.

Calculate:

(i) Life Cycle Cost (LCC) of the system, and [10 marks]

(ii) The unit electrical cost. [3 marks]

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